

**ATTRIBUTE BASED EXPLOSIVES FACILITY SITE PLANNING
AND EXPLOSIVES SAFETY MANAGEMENT
A TWENTY-FIRST CENTURY APPROACH**

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Terminology

In this paper, for simplification, we will use the term “facility” to refer to all objects which we will evaluate using explosives safety criteria. These include buildings, aircraft, open storage, utilities, etc.

Background

Integrated Systems Analysts, Inc. (ISA) and the Air Force Explosives Hazard Reduction (EHR) Program have been using the Assessment System for Hazard Surveys (ASHS) to evaluate explosives hazards on Air Force installations for more than six years. ASHS provides an installation wide view of hazards and explosives safety criteria disconnects. Explosives safety criteria appears very simple on its face, but when one attempts to apply it using computers it reveals its complexity.

We attempted to reverse-engineer the criteria, to see if we could derive the separation factors proscribed by DoD 6055.9-STD, by relating the levels of acceptable damage, explosives weights, and separation distances. We found that there was a poor correlation using this method. One reason is that many of the separation factors had been “corrected” to account for other phenomena. For example, inhabited building distance for less than 100,000 pounds of explosives is generally K-40 in the US. However, for hardened aircraft shelters, this was corrected to K-62 because of hazardous debris. Other artifacts of simplification contained in the DoD criteria even create a case where the required public traffic route separation distance is less than intraline distance for the same facility.

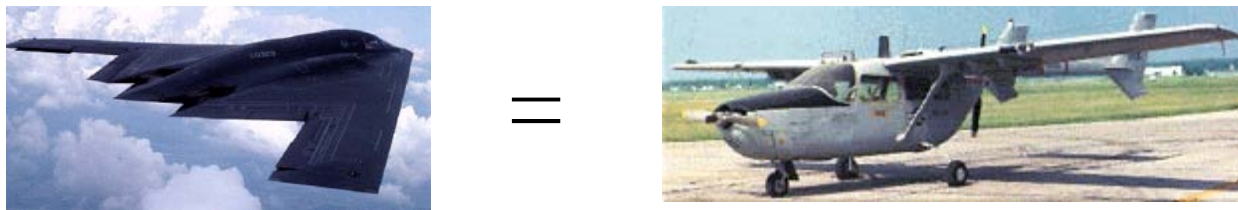
We have found existing explosives safety criteria to be overly complicated, sometimes self contradictory, and often in need of interpretation by explosives safety authorities (where you may receive different answers from different authorities). The following discussion, hopefully, provides some insight into an improved approach explosives safety.

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Overview

A new paradigm is needed for explosives facility site planning. More costly weapons systems, scarcity of resources, and reductions in personnel, drive a need for command authorities to have a more comprehensive view of the threat posed by explosives.

The current system provides permissible damage levels for various types and uses of facilities, and a complicated system of calculations and rules to predict whether these levels are exceeded. Computerization of the site planning process has significantly speeded up the measurement of distances and application of explosives safety rules, but is hobbled by the existing paradigm. The current system lumps sources and targets in general categories and consequently, a billion dollar B-2 bomber (a combat aircraft) receives the same protection from explosions as any other combat aircraft. Since the consequences of an explosives event are not obvious to command authorities, siting to the absolute minimum separation distance is encouraged.



Current explosives safety criteria treats a B-2 and an O-2 as equals

Attribute Based Site Planning (ABSP) is a new paradigm which gets away from the “Have you complied with the rule?” mentality and focuses on whether adequate protection is provided. Attributes such as hardness, accident likelihood, mission essentiality, and value would be assigned to each explosives source and target. Computer software would then evaluate each explosives source / target pair to determine the acceptability of the relationship. The computer would display mission impact, damage, level of threat, as well as compliance with minimum standards. Modern desktop and laptop computers have sufficient processing power to implement this paradigm, and to transition the static explosives safety site planning process into a dynamic explosives safety management system.

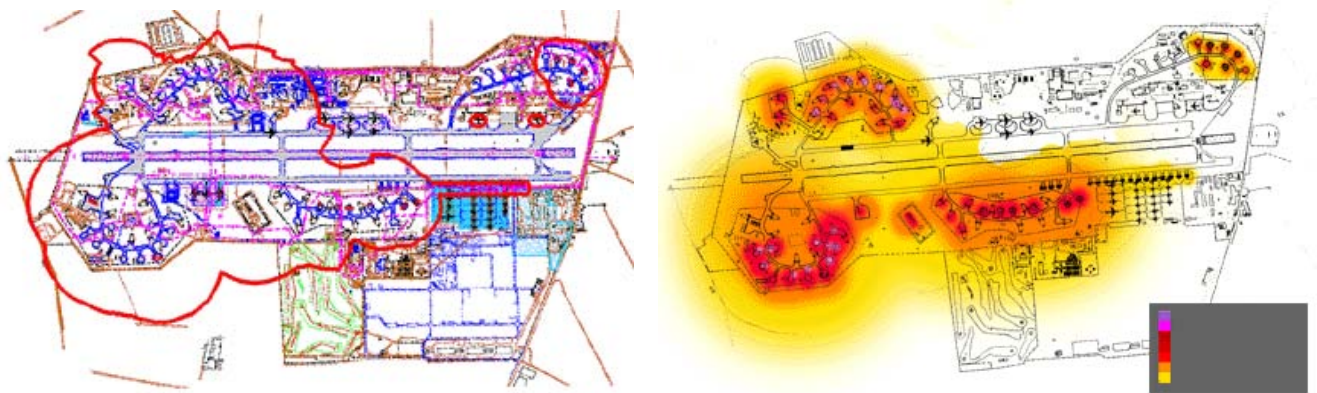
Current Practice

In current practice the explosives safety professional evaluates facility pair relationships by determining whether or not the distance between the facilities meets existing explosives safety criteria. The fundamental result is a go-no-go or meets-doesn't-meet criteria output. There is a hidden danger in this simple result. Explosives safety criteria is “minimum” criteria and may not provide sufficient protection to the people and assets exposed to the explosives threat. Explosives safety professionals and decision makers may be lulled into complacency because they believe that since criteria has been met, people and assets are not at risk.

Current explosives safety criteria was designed to be interpreted by humans and applied without the use of computers. Facilities are lumped into groups and consequently a lightweight pre-fabricated structure and a reinforced concrete structure often have the same separation

criteria. Very high value and mission-critical assets often have the same separation criteria as low value and non-mission-critical assets. Although one can review tables which reflect predicted damage levels, predicted damage is seldom presented to decision makers. These decision makers normally accept the siting based on the fact that it “meets criteria”, and unknowingly accept significant risk to people and mission critical assets.

We do a poor job of conveying the threat posed by explosives. Our site plans and facility maps generally show the overall inhabited building distance clear zone and little else. There normally no information presented to the decision makers which reflects the risks being assumed. This is analogous to viewing a weather map which displays only the fronts and high and low pressure centers. We need, instead, to be looking at the Doppler radar view. Attribute based site planning will provide that view, and more.



Comparison of weather map view and Doppler radar type view of explosives hazards

Attribute Based Planning

We must move away from the go-no-go results we use today and toward results which inform safety professionals, commanders and other decision makers of the various threats and risks that exist. In this way we can focus on the management of explosives hazards posed by the presence of our own munitions.

Separation factors will be derived based on attributes applied to both the potential explosion site (PES) and the exposed site (ES). Some attributes come quickly to mind such as hardness, mission criticality, and cost. Other attributes become obvious once the thought process has started. These include; the likelihood of an accident, strategic/tactical value, susceptibility, protective features such as barricades, whether the facility, asset, or human resource can be replaced, and others. A partial list of attributes can be found at appendix 1.

Attributes

We need a defined set of attributes. We will limit the set of attributes discussed here so we can explain the concept without undue complexity. Some attributes apply to both the PES and the ES. These are:

Hardness: Resistance to explosives effects (blast, debris, and thermal). At the implementation of attribute based planning it should be possible to assign hardness values based upon the facility type. For example, a hardened command post might be rated 1 and tent city 0.1.

Content Hardness: This tells us the effect on the contents of a facility once the facility is overcome by explosives effects. C/D 1.6 bombs might be rated 1, or less depending upon how rugged they are., soft cased aerial mines might be rated as 0.2, and sensitive test equipment as 0.1.

Cost:: What is the replacement cost of the facility?

Content Cost: What is the replacement cost of the contents.

Mission Criticality: If mission accomplishment relies on this facility it might be rated as a 1. If there are two items the mission criticality could be rated as 0.5. If 20 aircraft are assigned and 10 are the minimum to accomplish the mission each aircraft would have a mission essentiality value of 0.1.

Content Mission Criticality: The mission criticality of the contents of a facility. For example if a building contains the only electronic test set necessary to maintain the unit's combat computer systems, it would be rated as 1, if it contained half the bomb fuses it would be rated as 0.5, etc.

Aversion: What is the impact if people are killed in this facility: School children or infants might have a value of 1, military personnel in their barracks might have a factor of 0.7 and military personnel clearing minefields a value of 0.2.

Some attributes apply only to a PES.

Likelihood of an explosives incident: It should be possible, even without probabilistic studies (these would improve this attribute) to assign some relative values, for example a building containing C/D 1.6 munitions might have a likelihood value of 0.1, aircraft undergoing simultaneous loading and refueling might have a value of 0.5 and a remote operation involving machining of explosives might have a value of 0.9.

Explosives Content: Net explosives weight, C/D of the contents.

Blast Attenuation: Underground might have a value of 1, open aboveground storage 0.

Assigning Attributes:

Attribute based site planning would need a computerized system which we will refer to as the Attribute Based Site Planning System (ABSPS). The ABSPS would contain a facility database which would contain all the attributes of each facility. Attributes of contents of these facilities could be assigned directly to a facility or could be linked to other databases, such as the munitions accountable system.

Turning The Crank:

Initially calculations in the ABSPS would include both the existing compliance/noncompliance results and the attribute based results. The attribute based results would move more in the direction of physics based site planning in that it would consider the contents of the PES, its attenuation, and other factors to calculate the blast overpressure, blast impulse, debris density and thermal effects at the ES. Damage to the ES and its contents would be evaluated using its hardness, the hardness of its contents, orientation relative to the PES, and other appropriate attributes. If the ES also contains explosives the reaction of those explosives (direct propagation, delayed propagation, fire, etc.) would be derived. If the ABSPS predicts an explosive event at the ES this would input back into the system as a subsequent event.

Viewing The Results:

Just like our weather map there are many views of the results. We have listed only a few of them as examples. These views could easily be driven by database searches.

Compliance / Non-compliance: In this view facilities which do not meet existing criteria are highlighted. The PES would be assigned a color value based on the percentage of the required distance that was provided. In the case the PES threatened multiple ES the color would represent the color of the most restrictive exposure. Clicking on the PES would provide more information such as arrows to the threatened facilities and access to the database for full information.

Threatened ES By Quantity: How many threats are there to each ES. Each ES would be assigned a color based on the number of threats to it from other sources. Clicking on the ES would result in arrows being drawn from the threatening PES to the ES.

Threatened ES By Severity: This view would reflect the severity of the threat posed to each ES. A color value would be assigned based on the worst severity of the threat, for example propagation might be red and minor damage green. Clicking on the ES would result in appropriately colored arrows drawn from the threatening PESs and access to the database for full information.

Most Restrictive ES: Sometimes an ES places restrictions on many PESs. Change of use, relocation, or destruction of these facilities can often result in an increase in munitions storage / operations.

Most Threatening PES By Quantity: Which PESs threaten the largest number of other facilities. Each PES would be assigned a color value based on how many threats it poses to other facilities. Clicking on the PES would draw arrows to the threatened facilities and provide access to the database for further information.

PES Threat Severity: Each PES would be assigned a color value based on the worst threat it poses. Propagation might be assigned red and minor damage green, no damage would have no color. Clicking on the PES would draw appropriately colored arrows to the threatened facilities and provide access to the database for further information.

Other Views: By now the reader understands how the information would be presented but we will suggest a few other views.

PES Threat To Mission-Critical Facilities

PES Posing Greatest Aversion Risk

PES Posing Greatest Dollar Risk
PES Having High Likelihood Of Explosive Event

Dynamic Views:

Linkage with other systems such as munitions accountable systems, maintenance / operational control would provide safety professionals and commanders a dynamic representation of the safety posture of an installation. It could provide near real time feedback and alert decision makers when dangerous situations develop.

Conclusion: Attribute Based Site Planning is a needed step forward toward explosives safety management at installations. The increasing cost and scarcity of resources demands that commanders and decision makers have a clear view of hazards posed to our warfighting capability. Attribute based site planning can satisfy that need.

Partial List of Attributes

Threat	Likelihood	Peace
		War
	Structure	
	Contents	
	Mechanism	
		Blast
		Fragment
		Thermal
Toxic		
Target	Structure	
	Hardness	Blast
		Fragment
	Thermal	
	Toxic	
	Value	
		Impact Of Loss
		National
		Strategic
		Tactical
		Acquisition Cost
		Replaceability
		Replaceable
		Cost
		Time
Contents	Not Replaceable	
	Susceptibility	
	Blast	
	Fragment	
	Thermal	
Value	Toxic	
	Value	
		Impact Of Loss
		National
		Strategic
		Tactical
		Acquisition Cost
		Replaceability
		Replaceable
		Cost
Time		
Aversion	Not Replaceable	
	Occupants	
	Military	Service Members
		Civil Service
	Other Gov. Employees	
	Civilian	Adults
		Children
Mitigation	Secondary Hazards	